Changes of Claims Shown by Markings

--- An amendment paper August 15, 2007

10/820,561 For Reissue of U.S. Pat. 6,373,868

This amendment paper is same as before filed on July 17, 2006, except that the words of "the group consisting of " now have been changed to "--- the group including ---" in each dependent claim, such as in claims 2, 3, 5, 7 and 8. Obviously, the words of "the group consisting of " do not make any senses in a dependent claim. In addition, all bracketing and underlining is made in comparison to the original patent, not in comparison to any prior amendment in the reissue application. Further, there is no indication of a need to present an unchanged claim in the amendment paper according to 37 CFR 1.173.

[Note] There are two portions in the new claims, i.e., claims 1-9 and claims 10-15. Claim 1 and claim 10 are the two independent claims. Claims 1-9 are used to cover the situation with respect to a beam expanding laser cavity. Claims 10-15 are used to cover the situation with respect to a regular laser cavity. Each of them is very similar to the set of claims 1-9 in Pat. 6,373,868, in which only one independent claim covers these two situations. In other words, now claims 1-9 have been kept almost the same as before, except that the contents related to a regular laser cavity have been removed into the new claims 10-15.

What is claimed is:

1. (amended) In a method for configuring a standing-wave cavity arrangement for solid-state lasers in obtaining stable single-mode operation, whereby overcoming the major difficulty, with intracavity frequency conversions, typically in frequency doubling caused by the so-called "green problem", comprising the steps of
   (1) constructing a forming means for said cavity, including at least two end mirrors, <u>wherein said cavity is a beam expanding laser cavity;</u>
   (2) constructing a pump head means placed within said cavity for lasing at a fundamental wavelength; comprising the steps of
      A. selecting a solid-state laser medium means;
      B. selecting a pump source means including laser diode bars to provide relevant pumping beams for pumping said laser medium means; and

C. producing a gain region within said laser medium means by said <u>pump source means</u> [~~pumping beams~~];

(3) constructing a formation of wavelength selectivity with low insertion losses placed within said cavity, wherein the performance parameters of said formation are predetermined whereby to sufficiently and uniquely determine the laser's oscillating frequency and to force the laser to perform a stable single-mode or narrow band operation; and

(4) selecting an approach for <u>promoting single longitudinal mode operation</u> [~~eliminating or minimizing the spatial hole burning effect~~] from the group consisting of

A. a first approach, comprising

1) creating said gain region within a narrow area along the optical axis of said cavity and immediately adjacent to one of said end mirrors, and

2) selecting said formation from the group consisting of

~~[(a) a first formation comprising a monochromatic polarizer means,]~~

<u>a</u>[b]) a <u>first</u> [second] formation, built up of a Lyot filter and a one-dimensional beam expander means, and

<u>b</u>[c]) a <u>second</u> [third] formation, built up of a spectral filter means including at least one spectral filter, and a two-dimensional beam expander means to reduce insertion losses for said spectral filter means substantially; and

~~[(d) a fourth formation comprising an etalon; and]~~

B. a second approach, comprising

1) placing said pump head means between a pair of quarter-wave plates whereby producing the "twisted mode" operation, and

2) building said formation up of a spectral filter means consisting of at least one spectral filter, and a beam expander means to reduce insertion losses for said spectral filter means substantially.

2. (amended) In the method of claim 1, wherein said approach is said first approach, further comprising the steps of

(1) using a nonlinear crystal means arranged in an optimal condition including phase-matching for intracavity frequency conversion;

(2) maintaining the bandwidth of said formations to be smaller than the laser longitudinal oscillating mode interval of said cavity, and its free spectral range is larger than the FWHM of lasing bandwidth of the gain medium;

~~[(3)building said monochromatic polarizer means up of a polarizer and said nonlinear crystal means;]~~

(<u>3</u>[4])selecting said spectral filter from the group [consisting of] <u>including</u>

A. Lyot filters, formed by a polarizing means and a birefringent element; and

B. etalons, including 1) regular etalons, and 2) birefringent etalons which acts likewise as an additional Lyot filter in conjunction with said polarizing means;

(4[5])selecting said polarizing means from the group [consisting of] including 1) Brewster plate, 2) Brewster surface, and 3) Brewster reflector;

(5[6])selecting said birefringent element from the group [consisting of] including 1) said nonlinear crystal means, and 2) said birefringent etalon;

(6[7])selecting said laser cavity from the group [consisting of] including 1) regular standing-wave cavities; 2) V-shaped standing-wave cavities; and 3) L-shaped standing-wave cavities;

(7[8])building said two-dimensional beam expander means up of an AR coated lens pair; which additionally comprises the steps of

A. placing an aperture means at the focal plane of said object lens where a diffraction-limited point occurs, so that said beam expander means is configured as a spatial filter likewise in conjunction with said aperture means, whereby leading to TEM.sub.00 mode operation and an output with an excellent spatial quality;

B. keeping a proper defocusing for said beam expander means whereby achieving compensation of the thermal lens effect leading to stable laser operations; and

C. locating said nonlinear crystal means adjacent to said aperture means or within the unexpanded beam portion.

3. (amended) In the method of claim 2, wherein said spectral filter means consists of at least one Lyot filter, in order to protect the laser polarization at the fundamental wavelength from being altered or affected by the amount of birefringence of said nonlinear crystal means and said laser medium means; further comprising the steps of

(1) keeping said nonlinear crystal means to have a constant effective length to produce a phase retardation to be a half integral multiple of said fundamental wavelength, and

(2) selecting said laser medium from the group [consisting of] including 1) nonbirefringent laser medium, 2) laser medium made and oriented without the exhibition of birefringences, and 3) birefringent laser medium having a constant effective length to produce a phase retardation to be a half integral multiple of said fundamental wavelength.

5. (amended) In the method of claim 1, wherein said approach is said second approach, further comprising the steps of

(1) using a nonlinear crystal means arranged in an optimal condition including phase-matching for intracavity frequency conversion;

(2) maintaining the bandwidth of said spectral filter means is smaller than the laser longitudinal oscillating mode interval of said cavity, and its free spectral range is larger than the FWHM of lasing bandwidth of the gain medium, whereby to control the residual spatial hole burning;

(3) selecting said spectral filter from the group [consisting of] <u>including</u>

A. Lyot filters, formed by a polarizing means and a birefringent element; and

B. etalons, including 1) regular etalons, 2) said quarter-wave plate, and 3) birefringent etalons, in the later two cases said etalon acts likewise as an additional Lyot filter in conjunction with said polarizing means;

(4) selecting said polarizing means from the group [consisting of] <u>including</u> 1) Brewster plate, 2) Brewster surface, and 3) Brewster reflector;

(5) selecting said birefringent element from the group [consisting of] <u>including</u> 1) said nonlinear crystal means, 2) said pair of quarter-wave plates, and 3) said birefringent etalon;

(6) selecting said laser medium means from the group [consisting of] <u>including</u> 1) nonbirefringent laser medium, 2) laser medium made and oriented without the exhibition of birefringences, and 3) birefringent laser medium having a constant effective length to produce a phase retardation to be a half integral multiple of said fundamental wavelength, whereby to protect said "twisted mode" operation from being degraded by the amount of birefringence of said laser medium means;

(7) selecting said laser cavity from the group [consisting of] <u>including</u> 1) regular standing-wave cavities; 2) V-shaped standing-wave cavities; and 3) L-shaped standing-wave cavities;

(8) selecting said beam expander means to be a two-dimensional beam expander means built up of an AR coated lens pair; which additionally comprises the steps of

A. placing an aperture means at the focal plane of said object lens where a diffraction-limited point occurs, so that said beam expander means is configured as a spatial filter likewise in conjunction with said aperture means, whereby leading to TEM.sub.00 mode operation and an output with an excellent spatial quality;

B. keeping a proper defocusing for said beam expander means whereby achieving compensation of the thermal lens effect leading to stable laser operations; and

C. locating said nonlinear crystal means adjacent to said aperture means or within the unexpanded beam portion.

7. (amended) In the method of claim 1, wherein

(1) said approach is said second approach;

(2) said beam expander means is a prism beam expander which acts inherently as a polarizer likewise and is placed between said pump head means and said nonlinear crystal means, whereby 1) to reduce the insertion losses of intracavity optical elements, particularly for said etalon and said

Lyot filter, and 2) to provide both large and small beam waists in one compact cavity, whereby to be able to achieve mode-matched pumping and efficient intracavity frequency conversion at the same time;

(3) said gain region is in the shape of a thin layer whereby accommodating the one-dimensional mode expanding;

and further comprising the steps of

(4) using a nonlinear crystal means located within the unexpanded beamportion and arranged in an optimal condition including phase-matching for intracavity frequency conversion,

(5) maintaining the bandwidth of said spectral filter means is smaller than the laser longitudinal oscillating mode interval, and its free spectral range is larger than the FWHM of lasing bandwidth of the gain medium, whereby to control the residual spatial hole burning;

(6) selecting said spectral filter from the group [consisting of] <u>including</u>

A. Lyot filters, formed by said prism beam expander and a birefringent element; and

B. etalons, including 1) regular etalons, 2) said quarter-wave plate, and 3) birefringent etalons, wherein in the later two cases said etalon acts likewise as an additional Lyot filter in conjunction with said prism beam expander;

(7) selecting said birefringent element from the group [consisting of] <u>including</u> 1) said nonlinear crystal means, 2) said pair of quarter-wave plates, and 3) said birefringent etalon;

(8) selecting said laser medium means from the group [consisting of] <u>including</u> 1) nonbirefringent laser medium, 2) laser medium made and oriented without the exhibition of birefringences, and 3) birefringent laser medium having a constant effective length to produce a phase retardation to be a half integral multiple of said fundamental wavelength, whereby to protect said "twisted mode" operation from being degraded by the amount of birefringence of said laser medium means.

8. (amended) In the method of claim 7, further comprising the steps of

(1) keeping said nonlinear crystal means to have a constant effective length to produce a phase retardation to be a half integral multiple of said fundamental wavelength, whereby to protect the polarization and eigenvector of laser operation at the fundamental wavelength from being altered or affected by the amount of birefringence of said nonlinear crystal means;

(2) selecting said laser cavity from the group [consisting of] <u>including</u> 1) regular standing-wave cavities; 2) V-shaped standing-wave cavities; and 3) L-shaped standing-wave cavities;

(3) constructing a form for maintaining a constant cavity length for said cavity whereby stabilizing operation frequency, said form includes 1) selecting distance holders for said cavity forming means with a zero thermal expansion coefficient at room temperature, 2) selecting a temperature

compensation cavity structure for said cavity forming means, and 3) selecting a temperature control means for maintaining a constant temperature for said cavity;

(4) constructing a temperature control means for said nonlinear crystal means to maintain a constant temperature in the optimal condition whereby providing the best result for frequency conversion and minimizing cavity losses for the oscillating mode; and

(5) constructing a wavelength tuning form for the alignment of said etalon transmission peak to said laser oscillation frequency; said tuning form includes 1) temperature tuning, and 2) angle tuning, in which the rotation axis of said etalon must be perpendicular to the plan expanded by said prism beam expander whereby reducing the etalon walk-off loss.

9. (amended) In the method of claim 1, further selecting a nonlinear crystal means arranged in an optimal condition including phase-matching for intracavity frequency conversion, wherein said frequency conversion includes

(1) second harmonic generation, wherein said nonlinear crystal including KTP;

(2) resonantly enhanced second harmonic generation, wherein

A. said nonlinear crystal means including KTP;

B. said <u>formation</u> [spectral filter] is <u>a</u> [said] regular etalon; and

C. said cavity arrangement is configured to resonate at said second harmonic frequency by a phase compensator means or cavity distance adjustor means whereby largely enhancing the intensity of said second harmonic radiation and the conversion efficiency;

(3) third harmonic generation, wherein

said nonlinear crystal means is two nonlinear crystals positioned serially, in which the first crystal is set with type I phase-matching for doubling said fundamental radiation to produce the SHG, and the second crystal is set with type II phase-matching to mix said fundamental and second harmonic radiations so as to produce the THG;

(4) third harmonic generation with resonant harmonic generation, wherein

A. said nonlinear crystal means is two nonlinear crystals positioned serially, in which the first crystal is set with type I phase-matching for doubling said fundamental radiation to produce the SHG, and the second crystal is set with type II phase-matching to mix said fundamental and second harmonic radiations so as to produce the THG;

B. said <u>formation</u> [spectral filter] is <u>a</u> [said] regular etalon; and

C. said cavity arrangement is configured to resonate at said second harmonic frequency by a phase compensator means or cavity distance adjustor means whereby largely enhancing the intensity of said second harmonic radiation and the conversion efficiency;

(5) fourth harmonic generations, wherein

said nonlinear crystal means is three nonlinear crystals positioned serially, in which the first crystal is set with type I phase-matching for doubling said fundamental radiation to produce the SHG, the second crystal is set with type II phase-matching to mix said fundamental and second harmonic radiations for producing the THG, and the third crystal is set with type I phase-matching to mix said fundamental and third harmonic radiations so as to produce the FHG;

(6) fourth harmonic generation with resonant harmonic generation, wherein

A. said nonlinear crystal means is two nonlinear crystals positioned serially, in which the first crystal is used for doubling said fundamental radiation to a second harmonic radiation, and the second crystal is for doubling said second harmonic radiation to a quadrupling harmonic radiation;

B. said <u>formation</u> [spectral filter] is <u>a</u> [said] regular etalon; and

C. said cavity arrangement is configured to resonate at said second harmonic frequency by a phase compensator means or cavity distance adjustor means whereby largely enhancing the intensity of said second harmonic radiation and the conversion efficiency;

(7) frequency mixing, wherein

A. further selecting an input radiation, including a resonantly enhanced input; and

B. said nonlinear crystal means mixes said fundamental and said input radiations to a mixing radiation; and

(8) frequency mixing with resonant harmonic generation, wherein

A. further selecting an input radiation;

B. said nonlinear crystal means is two nonlinear crystals positioned serially, in which the first crystal is used for doubling said fundamental radiation to produce the SHG, and the second crystal mixes said second harmonic and said input radiations to a mixing radiation;

C. said <u>formation</u> [spectral filter] is <u>a</u> [said] regular etalon; and

D. said cavity arrangement is configured to resonate at said second harmonic frequency by a phase compensator means or cavity distance adjustor means whereby largely enhancing the intensity of said second harmonic radiation and the conversion efficiency.

<u>10. In a method for configuring a standing-wave cavity arrangement for solid-state lasers in obtaining stable single-mode operation, whereby overcoming the major difficulty with intracavity frequency conversions, typically in frequency doubling caused by the so-called "green problem", comprising the steps of</u>

<u>(1) constructing a forming means for said cavity, including at least two end mirrors, wherein said laser cavity is a regular laser cavity without a beam expander;</u>

(2) constructing a pump head means placed within said cavity for lasing at a fundamental wavelength; comprising the steps of

A. selecting a solid-state laser medium means;

B. selecting a pump source means including laser diode bars to provide relevant pumping beams for pumping said laser medium means; and

C. producing a gain region within said laser medium means by said pump source means;

(3) constructing a formation of wavelength selectivity with low insertion losses placed within said cavity, wherein the performance parameters of said formation are predetermined whereby to sufficiently and uniquely determine the laser's oscillating frequency and to force the laser to perform a stable single-mode or narrow band operation; and

(4) creating said gain region within a narrow area along the optical axis of said cavity and immediately adjacent to one of said end mirrors.

11. In the method of claim 10, said formation including

(1) a first formation comprising a monochromatic polarizer means; and

(2) a second formation comprising an etalon.

12. In the method of claim 11, further comprising the steps of

(1) using a nonlinear crystal means arranged in an optimal condition including phase-matching for intracavity frequency conversion;

(2) maintaining the bandwidth of said formation to be smaller than the laser longitudinal oscillating mode interval of said cavity, and its free spectral range is larger than the FWHM of lasing bandwidth of the gain medium;

(3) building said monochromatic polarizer means up of a polarizer and said nonlinear crystal means; and

(4) selecting said laser cavity from the group including 1) regular standing-wave cavities; 2) V-shaped standing-wave cavities; and 3) L-shaped standing-wave cavities.

13. In the method of claim 12, in order to protect the laser polarization at the fundamental wavelength from being altered or affected by the amount of birefringence of said nonlinear crystal means and said laser medium means; further comprising the steps of

(1) keeping said nonlinear crystal means to have a constant effective length to produce a phase retardation to be a half integral multiple of said fundamental wavelength; and

(2) selecting said laser medium from the group including 1) nonbirefringent laser medium, 2) laser medium made and oriented without the exhibition of birefringences, and 3) birefringent laser

medium having a constant effective length to produce a phase retardation to be a half integral multiple of said fundamental wavelength.

14. In the method of claim 12, further comprising the steps of
  (1) maintaining a constant cavity length whereby stabilizing operation frequency;
  (2) maintaining a constant temperature for said nonlinear crystal means whereby providing the best result for frequency conversion and minimizing cavity losses for the oscillating mode; and
  (3) constructing a wavelength tuning form for the alignment of said etalon transmission peak to said laser oscillation frequency.

15. In the method of claim 10, further selecting a nonlinear crystal means arranged in an optimal condition including phase-matching for intracavity frequency conversion, wherein said frequency conversion includes
  (1) second harmonic generation, wherein said nonlinear crystal including KTP;
  (2) resonantly enhanced second harmonic generation, wherein
    A. said nonlinear crystal means including KTP;
    B. said formation is a regular etalon; and
    C. said cavity arrangement is configured to resonate at said second harmonic frequency by a phase compensator means or cavity distance adjustor means whereby largely enhancing the intensity of said second harmonic radiation and the conversion efficiency;
  (3) third harmonic generation, wherein
    said nonlinear crystal means is two nonlinear crystals positioned serially, in which the first crystal is set with type I phase-matching for doubling said fundamental radiation to produce the SHG, and the second crystal is set with type II phase-matching to mix said fundamental and second harmonic radiations so as to produce the THG;
  (4) third harmonic generation with resonant harmonic generation, wherein
    A. said nonlinear crystal means is two nonlinear crystals positioned serially, in which the first crystal is set with type I phase-matching for doubling said fundamental radiation to produce the SHG, and the second crystal is set with type II phase-matching to mix said fundamental and second harmonic radiations so as to produce the THG;
    B. said formation is a regular etalon; and
    C. said cavity arrangement is configured to resonate at said second harmonic frequency by a phase compensator means or cavity distance adjustor means whereby largely enhancing the intensity of said second harmonic radiation and the conversion efficiency;
  (5) fourth harmonic generations, wherein

said nonlinear crystal means is three nonlinear crystals positioned serially, in which the first crystal is set with type I phase-matching for doubling said fundamental radiation to produce the SHG, the second crystal is set with type II phase-matching to mix said fundamental and second harmonic radiations for producing the THG, and the third crystal is set with type I phase-matching to mix said fundamental and third harmonic radiations so as to produce the FHG;

(6) fourth harmonic generation with resonant harmonic generation, wherein

A. said nonlinear crystal means is two nonlinear crystals positioned serially, in which the first crystal is used for doubling said fundamental radiation to a second harmonic radiation, and the second crystal is for doubling said second harmonic radiation to a quadrupling harmonic radiation;

B. said formation is a regular etalon; and

C. said cavity arrangement is configured to resonate at said second harmonic frequency by a phase compensator means or cavity distance adjustor means whereby largely enhancing the intensity of said second harmonic radiation and the conversion efficiency;

(7) frequency mixing, wherein

A. further selecting an input radiation, including a resonantly enhanced input; and

B. said nonlinear crystal means mixes said fundamental and said input radiations to a mixing radiation; and

(8) frequency mixing with resonant harmonic generation, wherein

A. further selecting an input radiation;

B. said nonlinear crystal means is two nonlinear crystals positioned serially, in which the first crystal is used for doubling said fundamental radiation to produce the SHG, and the second crystal mixes said second harmonic and said input radiations to a mixing radiation;

C. said formation is a regular etalon; and

D. said cavity arrangement is configured to resonate at said second harmonic frequency by a phase compensator means or cavity distance adjustor means whereby largely enhancing the intensity of said second harmonic radiation and the conversion efficiency.

Statement of Status/Support for all Changes to the Claims

August 15, 2007

This reissue is a broadening reissue, also is to make the claims more clear, simplify and readable, and to correct some inaccuracy which are caused by that in Pat. 6,373,868 only one single independent claim was used to cover too many different situations and approaches. On the other hand, several amendments also have been made in the specification. All of the drawings are kept exactly the same as before.

Long time ago in 1995 there had been two difficulties for applicant while he wrote the claims for his patent application, now Pat. 6,373,868. The first difficulty was how to avoid the overlapping with the parent patent. The second difficulty was how to use only one independent claim to do so in order to save money due to his very bad financial situation during that time.

In other words, this invention is the kind of root invention. It should have been fully covered by one simple independent claim without any problem if there was no the parent patent. On the other hand, it could be easily claimed by several independent claims in order to avoid the overlapping with the parent patent.

[Fact 1] The subject matter of Pat. 6,373,868 is for solving the well-known so-called "green problem". The subject matter of its parent patent of Pat. 5,515,394 is for solving mode-match pumping. However, the subject matter of Pat. 6,373,868 was been partially disclosed in its parent patent.

[Fact 2] The original patent application of Pat. 6,373,868 included several subject matters in which only one independent pending claim was for U.S. Pat. 6,373,868. The other subject matters have been issued with U.S. Pat. 6,873,639 later.

<u>In view of the above mentioned two difficulties, there have been two issues with the claims in Pat. 6,373,868.</u>

The first issue is that there should have been at least two independent claims to cover several different approaches and situations. One independent claim should be used to cover the situation with a regular laser cavity. The other one should be used to cover the situation with a beam expanding laser cavity. Further, only later has been partially disclosed in the parent patent. And only this part needs some limitation to avoid the overlapping with the parent patent.

[Fact 3] In Pat. 6,373,868 there is only one independent claim, i.e., claim1. In claim 1 (4) two approaches are discovered and specified to realize single longitudinal mode (SLM) operation in order to solve the well-known so-called "green problem". The step (4) A and B of Claim 1 define the first approach and second approach, respectively.
In the first approach, a formation of wavelength selectivity with low insertion losses, i.e., a low resolving-power spectral filter relative to a low frequency-selective loss has been used in cooperation with a pump head with a thin gain zone that leads to promoting single longitudinal mode operation.

The second issue is, therefore, only under the situation with the use of a beam expanding laser cavity it is necessary to have some limitation to avoid the overlapping with the parent patent, rather than under the situation with the use of a regular laser cavity.

Accordingly, in this reissue application, the following procedures have been applied in order to retrieve these two issues in Pat. 6,373,868.

There are two portions in the new claims, i.e., claims 1-9 and claims 10-15. Claim 1 and claim 10 are the two independent claims. Claims 1-9 are used to cover the situation with respect to a beam expanding laser cavity. Claims 10-15 are used to cover the situation with respect to a regular laser cavity. Each of them is very similar to the set of claims 1-9 in Pat. 6,373,868, in which only one independent claim covers these two situations.

In other words, now claims 1-9 have been kept almost the same as before, except that the contents related to a regular laser cavity have been taken away. And then new claims 10-15 are added for the situation of the regular laser cavity.

Further, the following amendment is made in claim 1 (4) in Pat. 6,373,868 for the new claim 1 (4),
Change "eliminating or minimizing the spatial hole-burning effect" to --- promoting single longitudinal mode operation ---.

[Fact 4] *It has already been pointed out in claim 1 (1) in Pat. 5,515,394, i.e., the parent patent, that "whereby minimizing or eliminating the spatial hole-burning effect to facilitate single longitudinal mode operation." Therefore, the approach selected in claim 1 (4) in Pat. 6,373,868 is directly for promoting SLM operation. As the further explanation in laser physics in detail, please refer to the following Appendix "More Explanation in Laser Physics for Fact 4".*

Moreover, there are two modifications in the second portion of the new claims 10-15. The first one is to get rid of the contents related to the situation with a beam expanding laser cavity. The second modification is that, a limitation from the independent claim is removed to the next succeeding dependent claim.

[Fact 5] *In claim 1(4) in Pat. 6,373,868, it is not necessary to stipulate said formation of wavelength selectivity in detail in the first approach to limit its coverage. (Please refer to the above "the second issue".) Accordingly, those specified members for said formation, which are recited in a Markush group, now have been removed from the independent claim into the succeeding dependent claim in the new set of the claims.*

In conclusion, there are three amendments in the new claims 1-15. Firstly, the new claims 1-9 have been kept almost the same as before for the beam expanding laser cavity. And then new claims 10-15 are added for the regular laser cavity. Secondly, one limitation in the independent claim 10 is removed into the next dependent claim 11. The third one in new claim 1 is mentioned above in [Fact 4]. In addition, the words of "pumping beams" have been replaced by the words of "pump source" in the new claim 1(2)C and claim 10(2)C. Because the matter related to the "pumping beams" was not elected for the subject patent. In other words, the "pump source" in the subject patent is not limited to "pumping beams".

APPENDIX

[More Explanation in Laser Physics for Fact 4]

The two approaches in Claim 1 (4) A and B are to directly create a favorable circumstance to promote SLM operation, even though people usually call it as the term of "eliminating or minimizing the spatial hole burning effect" in laser physics.

The real meaning and intention in the first approach in claim 1 (4) A is to create a favorable circumstance to promote SLM operation. In such a circumstance, all possible longitudinal modes have about an equal chance to extract the available gain. That mode which begins to oscillate first wins the "mode-competition" and deprives the others of the gain needed to oscillate, thereby forcing single axial-mode operation. In view of that all of the above sentences is too long to be presented, therefore, people usually use the term of "eliminating or minimizing the spatial hole burning effect" in order to brief it.

Further, what is the physics property for the thin gain region in contact with an end resonator mirror? It is the only narrow area within the laser cavity where is exactly in phase for all possible longitudinal-modes of laser operations. In such a circumstance, all the longitudinal modes have a common spatial node at the surface of the mirror, and access to the same population inversion since in this narrow excited region. The mode with the highest cross section for stimulated emission will oscillate first, saturation the population inversion and reducing the gain of the medium to the threshold gain of this first mode. This modification of the population inversion reduces the gain available to the other longitudinal modes. Other cavity modes with lower cross sections can not reach threshold since they use the same population distribution as the highest gain mode.

As a conclusion, there still exists spatial hole burning, but due to the overlap among many possible standing-wave patterns (or many possible longitudinal modes) within this narrow excited region, spatial hole burning would not cause any problem for SLM operation. Therefore, it should be more precisely to say that: the selected approach in claim 1 (4) is for eliminating or minimizing the favorable condition for multi-mode operation so as to promote SLM operation, rather than to eradicate spatial hole burning.

[What is "Green Problem"]

It had been harassed and frustrated for many world-class scientists and engineers, for almost ten years from 1986 to 1995, to obtain stable continue wave (CW) visible light, typically green light from the new generation laser system, i.e., DPSS lasers. It is that the well-known so-called "green problem". The essential difficulty in solving the "green problem" results from that, there is a persistent obstacle in effectively obtaining single longitudinal mode (SLM) CW operation due to the favorable condition for multi-mode operation in solid-state lasers. The related critical design issues are considered to be extremely tough during that time.

[What is Claimed in My Patent and Its Patentability]

In U.S. Pat. 6,373,868 a favorable condition for SLM operation is created by means of a thin gain region in contact with an end cavity mirror. Then a low resolving-power spectral filter with low loss, such as Lyot filter or low-finesse etalon or the like, is used to realize single axial-mode CW operation and stable intracavity SHG output, whereby overcoming the major difficulty with intracavity frequency conversions, i.e., the well-known so-called "green problem". Such a laser arrangement is universal for all kind of solid-state lasers.

In order to overcome the well-known so-called "green problem", nobody in the prior art has ever suggested and considered the use of a low resolving-power spectral filter relative to a low frequency-selective loss in cooperation with a pump head with a thin gain zone that leads to promoting SLM operation. This is the first approach defined by the step (4) A of Claim 1. Also, nobody in the prior art has ever suggested and considered the use of a spectral filter in cooperation with a beam expander to reduce the insertion losses. This is the second approach defined by the step (4) B of Claim 1 in U.S. Pat. 6,373,868.